

Conference Reports

New Results in LCA Research at the Swiss Federal Institute of Technology (ETH) Zurich

Conference held at ETH Zurich on August 26, 1998

Author: Rolf Frischknecht, ESU-services, Zentralstrasse 8, CH-8610 Uster, Switzerland

1 Introduction

On August 26 the conference "New results from LCA research at ETH Zurich" took place in Zurich attracting more than 100 LCA practitioners and researchers. The goal of the conference was twofold: On the one hand, new methodological approaches in Life Cycle Inventory Analysis (LCI) and in Life Cycle Impact Assessment (LCIA) were presented, developed by four Ph.D. students finalising their doctoral thesis this year. On the other hand, Professors at ETH who acted as examiners and co-examiners provided an insight into the history, the present situation and the future of LCA research at ETH Zurich.

2 Results from LCA research

Models for Uncertainty in the LCA Framework and Approximate Valuation Methods

Christian POHL and Matjaz ROS presented fuzzy set models to analyse and process imprecision and uncertainty in LCI, LCIA and valuation. Based on the distinction between a realist's and a relativist's view of the world (the former searching for the "true" LCA, the latter believing that several LCA on the same topic may be right, even if they lead to opposite results) they showed that both of them have valid arguments for their point of view, be it in discussion of uncertainty in either LCI, LCIA or valuation.

Matjaz ROS subsequently compared 3 different models to assess quantitative uncertainty data in LCA: probabilities, interval data and fuzzy sets. Investigating in related literature and using a sample public data set in LCI and LCIA he compared the properties and "hidden assumptions" of the models. He pointed out that probability distributions often reflect a too "optimistic view" of data quality which in practice is hard to fulfil. Error intervals and algorithmically related fuzzy sets place fewer requirements on LCA-data and allow for a more flexible and robust quantitative modelling.

Christian POHL finally presented a fuzzy valuation approach for LCA based on approximate reasoning. Taking pattern from the CML-method on the one hand and on the Verbal-Argumentative Overall Evaluation (German Federal Environmental Agency) on the other hand, he showed that approximate reasoning is a computable "missing link" between qualitative and quantitative valuation concepts.

Compared to "one score" valuation methods approximate reasoning seems to be more robust: it is insensitive to small input parameter changes, whereas larger changes are represented adequately. This may be interesting in relation to the valuation method dispute, which, among POHL, is mainly driven by small differences in details and simultaneous similarity in overall weighting tendencies of the "one-score" approaches. The approximate reasoning therefore may be used as an alternative to the "use many methods" approach.

Scope-Dependent Inventory Models for Decision Support

ROLF FRISCHKNECHT presented a framework which classifies typical goals of an LCA (product development, strategic planning, etc.) and helps to identify the adequate Inventory model and underlying dataset. Starting from the guiding principle that LCA results should complement economic information it is deducted that LCI models, i.e., the network of individual unit processes contributing to the production of a certain functional unit, should be set up based on financial or contractual relation between these functional units. However, the amount of energy, raw material or service needed is still measured in physical terms. The financial or contractual relations are only used to identify the provider of energy carriers, raw materials or services. FRISCHKNECHT showed that LCI models may best be discriminated by the time horizon for which a decision is made and he therefore introduced a short-, a long- and a very long term model. These change-oriented models used for decision support are different from a descriptive or status quo model which may mainly be used for environmental reporting (what happened last year?) in that marginal instead of average technologies are applied. Examples from the electricity sector helped to illustrate the theoretical concept. He could show that the choice of the scenario about the development of electricity consumption (future increase or decrease) in a country strongly influences the environmental performance of electricity.

Perspectives in Life Cycle Impact Assessment: A Structured Approach to Combine Models of the Technosphere, Ecosphere and Valuesphere

PATRICK HOFSTETTER presented a new perspective on LCA and showed the implications on the phase of Impact Assessment.

He developed a structured approach for the combination and integration of the models used to describe the valuesphere (Cultural Theory), the ecosphere (mainly fate, expo-

sure, and effect models) and the technosphere (inventory model). The use of archetypal perspectives taken from the Cultural Theory enables a new approach to make compatible value choices in all phases of an LCA. Based on this three indices have been developed consisting of an assessment of the damages where causalities are known, of the unknown damages, and of the manageability of the damages. The proxy index for the unknown damage is based on the ratio of the bioconcentration factors and the geogenic plus anthropogenic world-wide emissions. The index of manageability is composed by indicators for the ease of damage reduction, the excess of target damage, and the success of regulation. Next to the operationalisation of "unknown damage" and "manageability" results for the health damages to humans were presented for carcinogenic and respiratory effects. The damages were measured with an adaptation of the DALYs-concept (disability adjusted life years), suggested and used by health economists (for further information on the use of Cultural Theory and the damage assessment see GOEDKOOP et al., *Int. J. LCA* (6) 1998). This new threefold structure allows to support decisions to be taken by the three archetypes considered to be active in decision making (individualists, hierarchists, egalitarians). Consequently, the decision support will be dependent from the cultural perspective considered relevant for the decision at hand.

3 History, Present and Future of LCA Research at ETH Zurich

LCA Research at ETH Zurich

Prof. Dr. P. SUTER asked why a technical university is working on subjects like Life Cycle Assessment (LCA) since more than 15 years. He stated that the initial impulse came from the political side when the themes of ecology and sustainability had arisen political interest. Such a situation may have threefold implications to the academic world: Firstly, questions from governmental boards are asked whether some technologies shall be politically encouraged or prevented; secondly the economy is looking for independent evaluations, recognising that environmental arguments are important on the market; and thirdly the students feel concerned by environmental considerations and methods, expecting their incorporation into the courses.

If these requirements should be fulfilled, expertise had to be obtained on the basis of serious work by partly involving students. Soon it was also evident, that environmental assessment does not only mean accounting, but poses serious methodological problems which in turn gave (and will continue to give) opportunities for interesting research and Ph.D.-theses, mostly on an interdisciplinary level.

So the field of LCA may also show that serious work at universities does not at all need an ivory tower situation, but can be fully linked to important contemporary items, without losing its independence.

LCA in Projects of the Alliance for Global Sustainability

Prof. Dr. D. SPRENG, gave an overview of projects carried out within the Alliance for Global Sustainability (AGS), a collaboration of MIT, Cambridge MA, the University of Tokyo and the Swiss Federal Institutes of Technology (ETH). The proposals of the various AGS-projects were analysed to investigate whether and how Life Cycle Assessment is used by the researchers from various disciplines. The analysis of the collected data showed that LCA methodology and LCA-data are widely used, mainly by engineers as an environmental indicator in order to assess environmental impacts of specific technologies, products or processes. A couple of projects aim at improving the applicability of LCA methodology by simplifying and integrating them into work processes, such as the computerised design of mechanical parts and management procedures. No projects could be identified which focus on the further sophistication of the LCA methodology.

Centre for Life Cycle Inventories in the ETH-Domain

Prof. Dr. K. HUNGERBÜHLER, head of the steering committee of the Centre for Life-Cycle Inventories in the ETH domain, introduced the project ECOINVENT 2000, a follow-up project of the energy systems database project of the early nineties initiated by Prof. Dr. P. SUTER and carried out under his guidance. The project ECOINVENT 2000 aims at a harmonised dataset of LCA inventory data for investment and consumer goods. For that purpose Swiss research institutes¹ working on LCA co-operate and will agree on a common dataformat and common principles how to represent processes in an LCI model. In a first phase until December 1998, the data warehouse will be specified based on the needs of the partner institutes. In a second phase until the end of 1999, the data warehouse will be realised and the different databases (e.g., the Ecoinvent database at ETH Zurich, the EcoPro database of EMPA St. Gall and the building materials database of EMPA Dübendorf) will be put into this data warehouse. The datasets will be evaluated and harmonised in order to only keep one dataset per material, energy carrier or product with identical system boundaries and production technology. The data warehouse will be – on a technical level – completely compatible with the SPOLD data exchange format.

The Future for LCA-Research at ETH Zurich

Prof. Dr. R. SCHOLZ, introduced LCA as a tool having the potential to monitor sustainable development. He showed the different types and contexts in which LCA may be applied. In particular, he differentiated between the use of LCA in product comparison and evaluation where robust results are required and the use of LCA as a tool to gain knowledge in describing the relation between humans and nature. The latter is necessary because mankind lacks a natural senso-

¹ Swiss Federal Institute of Technology (ETH) Zürich, Swiss Federal Institute of Technology (ETH) Lausanne, Swiss Federal Laboratories of Materials Testing and Research (EMPA) St. Gall, Swiss Federal Laboratories of Materials Testing and Research (EMPA) Dübendorf, Paul Scherrer Institute (PSI) Villigen, Swiss Federal Institute for Environmental Science and Technology (EAWAG) Dübendorf.

rium for far-reaching environmental impacts. Within these contexts contradicting requirements may be formulated in view of the further development of LCA and of LCA research at ETH. Implementation-oriented research work is required on the implementation of LCA in companies, on the acceptance of LCA or certain LCIA-procedures, and on an evaluation of effects caused by applying LCA and implementing its results. SCHOLZ identified two pitfalls of LCA: On the one hand, the fragility of knowledge asks for special strategies to be capable of reacting to today's changing knowledge in science. On the other, LCA practice and research needs to overcome the claim of totality. Furthermore he highlighted that LCA is already well embedded at ETH Zurich in knowledge generation (e.g., fate analysis, toxicology), in technology development (e.g., in the building sector), and in the environmental sciences department (e.g., modelling of environmental systems). It is further planned to introduce LCA and environmental impact assessment as one part of the technical education of environmental scientists at ETH Zurich.

For More Information:

The thesis "Life Cycle Inventory Analysis for Decision-Making" written by R. FRISCHKNECHT is available at ESU-services, Zentralstrasse 8, CH-8610 Uster, Tel. +41-1-940 61 91, e-mail: esu-services@access.ch.

It costs CHF 79.- per copy plus CHF 10.- for postage and packaging within European countries and CHF 20.- for overseas countries.

The thesis "Perspectives in Life Cycle Impact Assessment" written by P. HOFSTETTER is available in the book-trade (ISBN: 0-7923-8377-X) or directly from Kluwers via <http://www.wkap.nl/book.htm/0-7923-8377-X>.

The thesis of C. POHL is in printing. If you would like to be informed as soon as it is available, please send an e-mail with your address to Christian Pohl (pohl@collegium.ethz.ch).

The thesis "Unsicherheit und Fuzziness in ökologischen Bewertungen – Orientierungen zu einer robusten Praxis der Ökobilanzierung" written by M. Ros is available at Matjaz Ros, Tobeleggweg 4, CH-8049 Zurich, e-mail: ros@uns.umnv.ethz.ch

It costs CHF 49.- per copy plus CHF 10.- for postage and packaging within European countries and CHF 20.- for overseas countries.

For more information about research activities of Profs. K. HUNGERBÜHLER, R. SCHOLZ and D. SPRENG at ETH Zurich you may visit the following web-sites:

Prof. Dr. K. HUNGERBÜHLER: <http://www.chem.ethz.ch/D-CHEM-Prof/hungerbuehler/hungerb.html>

Prof. Dr. R.W. SCHOLZ: <http://www.uns.umnw.ethz.ch/>

Prof. Dr. D. SPRENG: <http://www.energieanalysen.ethz.ch/>

Software Corner

Environmental Data, Analysis and Comparison for Corrugated Packaging

Since 1994, three European Associations have been working together to provide industry and its customers with up-to-date knowledge based on facts which concern the impact of industry on the environment. This knowledge helps to integrate environmental affairs into decision making. It is the basis for product and process improvements, thus enabling a responsible and pro-active industry attitude towards the environment.

The three Associations are:

- FEFCO (European Federation of Corrugated Board Manufacturers)
- GO (Groupement Ondulé, European Association of makers of Corrugated Base Papers)
- KI (Kraft Institute, Association of the Virgin Fibre Based Producers of Corrugated Board Materials in Europe)

Each Association regularly collects environmental data from its members. The weighted averages of the collected data are published together in a report "European Database for Corrugated Life Cycle Studies". The Associations have developed standardised LCA (software tool) that is based on the data and methodology as described in the report.

For more information, please contact:

FEFCO
37, rue d'Amsterdam
F-75008 Paris
Phone: +33-1-53 20 66 80
Fax: +33-1-42 81 97 07

Groupement Ondulé
Jahnstr. 93
D-64285 Darmstadt
Phone: +49-6151-44501
Fax: +49-6151-421702

Kraft Institute
Norrtullsgatan 43
S-11345 Stockholm
Phone: +46-8-303440
Fax: +46-8-341920

European Database for Corrugated Life Cycle Studies

The report contains:

- Descriptions of the production systems
- Methodology questions
- Data for consumption of raw materials, additives and water
- Data for emissions to air, water and waste

LCA software-tool for corrugated packaging

A special LCA software-tool for corrugated board has been developed for members of the three Associations; it is, however, also available for non-members through FEFCO. It is designed for users that have only elementary knowledge of LCA. It is based on SimaPro 4 from Pré Consultants. The software uses the most recent data from the report "European Database for Corrugated Life Cycle Studies" and the closed-loop approach as a basis for the calculations. It enables the user to enter data according to his own situation (box design, transportation distances, etc.) and analyses and compares different options.